WRF Nesting: Set Up and Run

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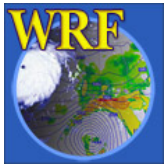
Outline

- General comments
- Nest namelist options
- Running WRF with nests
  - NMM case: one-way, two-way nesting
  - ARW case: two-way nesting
  - ARW moving nest
  - ARW one-way nesting
- Summary



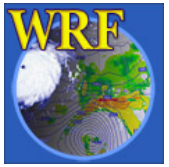
Before You Run ..

- Make sure you have selected basic nest compile options and appropriate executables are created in **`WRFV3/main/`** directory:

  For ARW:
  - **`ideal.exe`**
  - **`real.exe`**
  - **`wrf.exe`**
  - **`ndown.exe`**
  - **`tc.exe`**

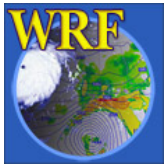
  For NMM:
  - **`real_nmm.exe`**
  - **`wrf.exe`**

- If you are running a real-data case, be sure that files for *nest* domains from WPS are generated:
  - **`met_em.d01.<date>`**, **`met_em.d0*.<date>`** for ARW or
  - **`met_nmm.d01.<date>`**, **`geo_nmm_nest.l0*.nc`** for NMM



Steps to Run (same as before)

1. cd to *run/* or one of the *test case* directories
2. Link or copy WPS output files to the directory for real-data cases
3. Edit *namelist.input* file for the appropriate grid and times of the case
4. Run initialization program (*real.exe*, or *real_nmm.exe*) as in the single domain case
5. Run model executable, *wrf.exe*

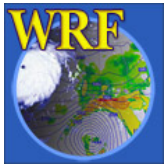


All in the namelist…

- Nearly all controls for a nested run can be achieved by editing the namelist file.
- Look at nest specific namelist options

Important to note:

- Key variable: **`max_dom`** must be set to >= 2
- Need to pay attention to multi-column namelists



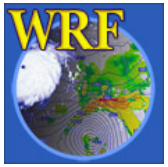
Nest namelist Options

&time_control

```
run_days            = 0,
run_hours           = 24,
run_minutes         = 0,
run_seconds         = 0,
start_year          = 2000, 2000, 2000,
start_month         = 01,   01,   01,
start_day           = 24,   24,   24,
start_hour          = 12,   12,   12,
start_minute        = 00,   00,   00,
start_second        = 00,   00,   00,
end_year            = 2000, 2000, 2000,
end_month           = 01,   01,   01,
end_day             = 25,   25,   25,
end_hour            = 12,   12,   12,
end_minute          = 00,   00,   00,
end_second          = 00,   00,   00,
interval_seconds    = 21600
```

First column: domain 1 option

These control the start and end times of the nests. They can be different from the parent domain, but must fit in the time window of the parent domain

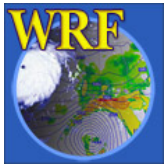


&time_control

```
interval_seconds     = 21600
history_interval     = 180,  60,   60,
frame_per_outfile    = 1000, 1000, 1000,
restart_interval     = 360,
```

History output may be split into multiple files

- History files are written separately for each domains
- History intervals may be different for different domains
- restart files are also written one per domain



&time_control

Nest input option: ARW only

```
input_from_file  = .true., .true., .true.,
fine_input_stream   = 0, 2, 2,
```

Specify what fields to use in nest input: they can be all (0), or data specified in I/O stream 2 in Regsitry (2). Useful for a nest starting at a later time.

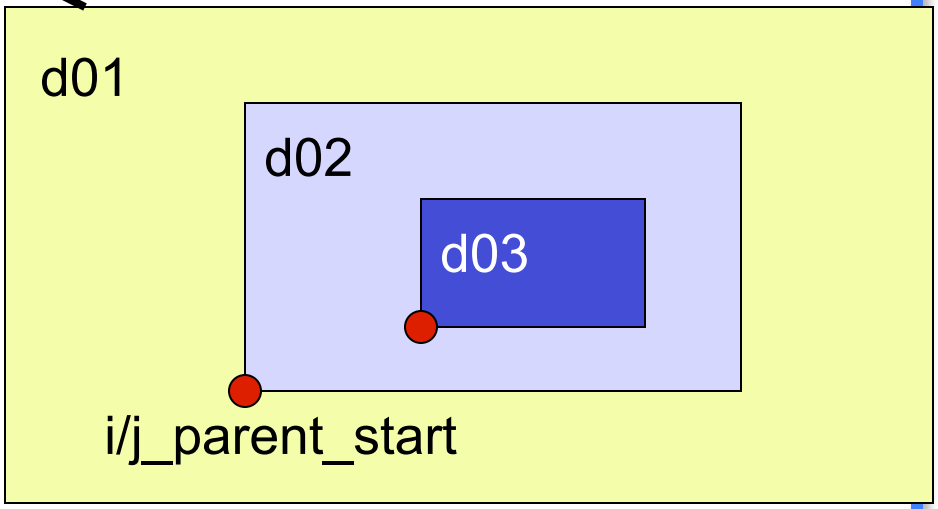
Whether to produce in *real* and use nest wrfinput files in *wrf*. This is usually the case for real-data runs. For idealized nest runs, set it to .false. .

&domains

```
max_dom   = 3,
e_we      = 74, 112,94,
e_sn      = 61, 97, 91,
e_vert    = 28, 28, 28,
grid_id          = 1,  2,  3,
parent_id        = 0,  1,  2,
i_parent_start = 0, 31, 30,
j_parent_start = 0, 17, 30,
```

Activate nests: no. of domains to run

Dimensions of all domains; same as in WPS.



Make sure the nest domain parameters match those defined in WPS

&domains

ARW

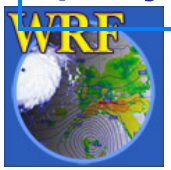
```
dx = 30000, 10000, 3333.33,
dy = 30000, 10000, 3333.33,
parent_grid_ratio = 1, 3, 3,
parent_time_step_ratio = 1,3,3,
```

All 4 variables must be specified. *Grid ratio* can be any integer, and *time step ratio* can be different from grid ratio. Grid distance is in meters, even for lat/lon map projection.

NMM

```
dx = 0.096290,
dy = 0.096011,
parent_grid_ratio = 1,
parent_time_step_ratio = 1,
```

Values in nest columns are ignored. Everything is defined by 1:3 ratio in the model.

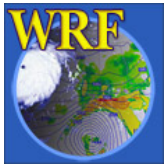


&domains

```
feedback        = 1,
smooth_option = 2,
```

When feedback is on, this option can be selected to smooth the area in the parent domain where the nest is. Valid values are 0,1,2.

Whether nest will overwrite parent domain results. Setting *feedback*=0 ➔ 'one-way' nesting in a concurrent run.



&bdy_control

```
spec_bdy_width = 5,  (1 for NMM)
spec_zone      = 1,  (ARW only)
relax_zone     = 4,  (ARW only)
specified      = .T.,.F.,.F.,
nested         = .F.,.T.,.T.,
```

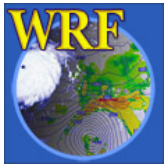
Boundary condition option for domain 1.

Boundary condition option for nests.

May change *relax_zone* and *spec_bdy_width* for ARW

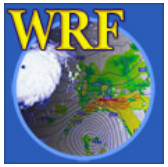
Other notes on namelists

- Use same physics options for all domains.
  - An exception is cumulus scheme. One may need to turn it off for a nest that has grid distance of a few kilometers.
- Also use same physics calling frequency (e.g. **`radt, cudt,`** etc.) in all domains.

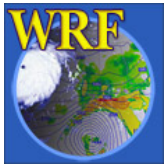


Where do I start?

- Always start with a *namelist* template provided in a test case directory, whether it is a ideal case, ARW or NMM.
- Not all namelists are function of domains. If in doubt, check Registry.EM or Registry.NMM and registry.io_boilerplate (look for string 'namelist').
- Use document to guide the modification of the namelist values:
  - run/README.namelist
  - User's Guide, Chapter 5



Running NMM Nested Case



Running NMM Nested Cases

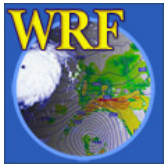
- Files available from WPS:

  met_nmm.d01.<date>

  geo_nmm_nest.l0*.nc,.. (multi files from **geogrid**)

- Link or copy WPS output files to the run directory:

```
cd test/nmm_real
ln -s ../../../WPS/met_nmm.d01.*   .
ln -s ../../../WPS/geo_nmm_nest.*   .
```



Running NMM Nested Cases

- Edit **namelist.input** file for runtime options (set **max_dom >= 2** for a nest run)

- Run the real-data initialization program (MPI only):

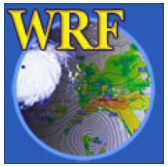
  mpirun -np *N* ./real_nmm.exe

- Successfully running this program will create model initial and boundary files:

  wrfinput_d01

  wrfbdy_d01

  geo_nmm_nest.l01.nc ← from geogrid



Running NMM Nested Cases

- Run the model executable by typing (MPI only):

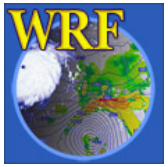
```
mpirun -np N ./wrf.exe
```

- Successfully running the model will create model *history* files, one for each domain:

```
wrfout_d01_2005-08-28_00:00:00
wrfout_d02_2005-08-28_00:00:00
```

And *restart* file if selected:

```
wrfrst_d01_<date>, wrfrst_d02_<date>
```



Running ARW Nested Case

Running ARW Nested Cases

- Files available from WPS:

  met_em.d01.<*date*>

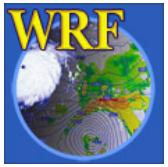
  met_em.d02.<*date*> (at least one time)

  …

- Link or copy WPS output files to the run directory:

  cd test/*em_real*

  ln -s ../../../WPS/met_em.* .



Running ARW Nested Cases

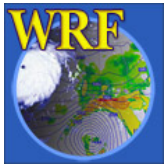
- Edit **`namelist.input`** file for runtime options (set **`max_dom >= 2`** in **`&domains`** for a nested run)

- Run the real-data initialization program:

  `./real.exe,` if compiled serially / SMP, or

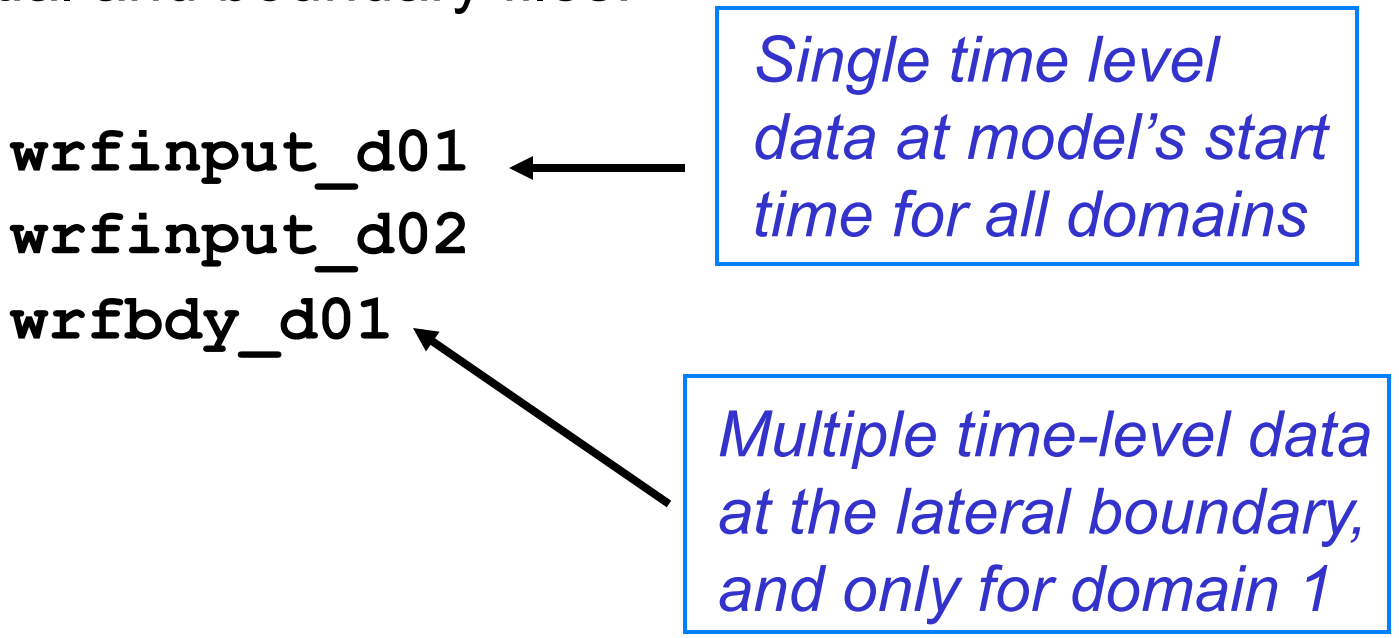
  `mpirun -np N ./real.exe,` for a MPI job

  where ***N*** is the number of processors requested



Running ARW Nested Cases

- Successfully running this program will create model initial and boundary files:



Running ARW Nested Cases

- Run the model executable by typing:

  `./wrf.exe >& wrf.out &`

  or

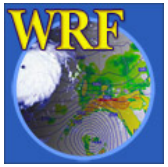
  `mpirun -np N ./wrf.exe &`

- Successfully running the model will create model *history* files, one for each domain:

  `wrfout_d01_2005-08-28_00:00:00`
  `wrfout_d02_2005-08-28_00:00:00`

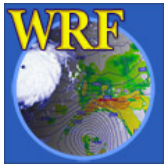
  And *restart* file if selected:

  `wrfrst_d01_<date>, wrfrst_d02_<date>`



Moving Nest Case (ARW only)

- The main reason for using this option is to run the model economically.
- Must choose correct compile options when creating **`configure.wrf`** file
  - Choose preset move, or vortex following
- Other options are controlled by the namelists.
- Can do specified move, and automatic vortex tracking (for tropical cyclone application).
- All nest domains can move.



Specified Moving Case

- Namelists in **`&domains`**:

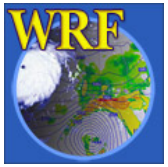
  `num_moves, move_id, move_interval,`
  `move_cd_x, move_cd_y`

  ➔ nest can only move one parent-grid-cell at a time.

  i.e., `move_cd_x = 1, -1,` or `0`

- Also specify initial nest location:

  `i_parent_start, j_parent_start`



Automatic Moving Case

- Tropical cyclone applications only.
- Works better for well developed storms.
- Namelists in **`&domains`**:

  `vortex_interval` (default 15 min)

  `max_vortex_speed` (default 40 m/s)

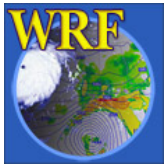
  `corral_dist` (default 8 coarse grid cells)

  `track_level` (default 50000 Pa)

  `time_to_move` (default is 0 h for all nests)

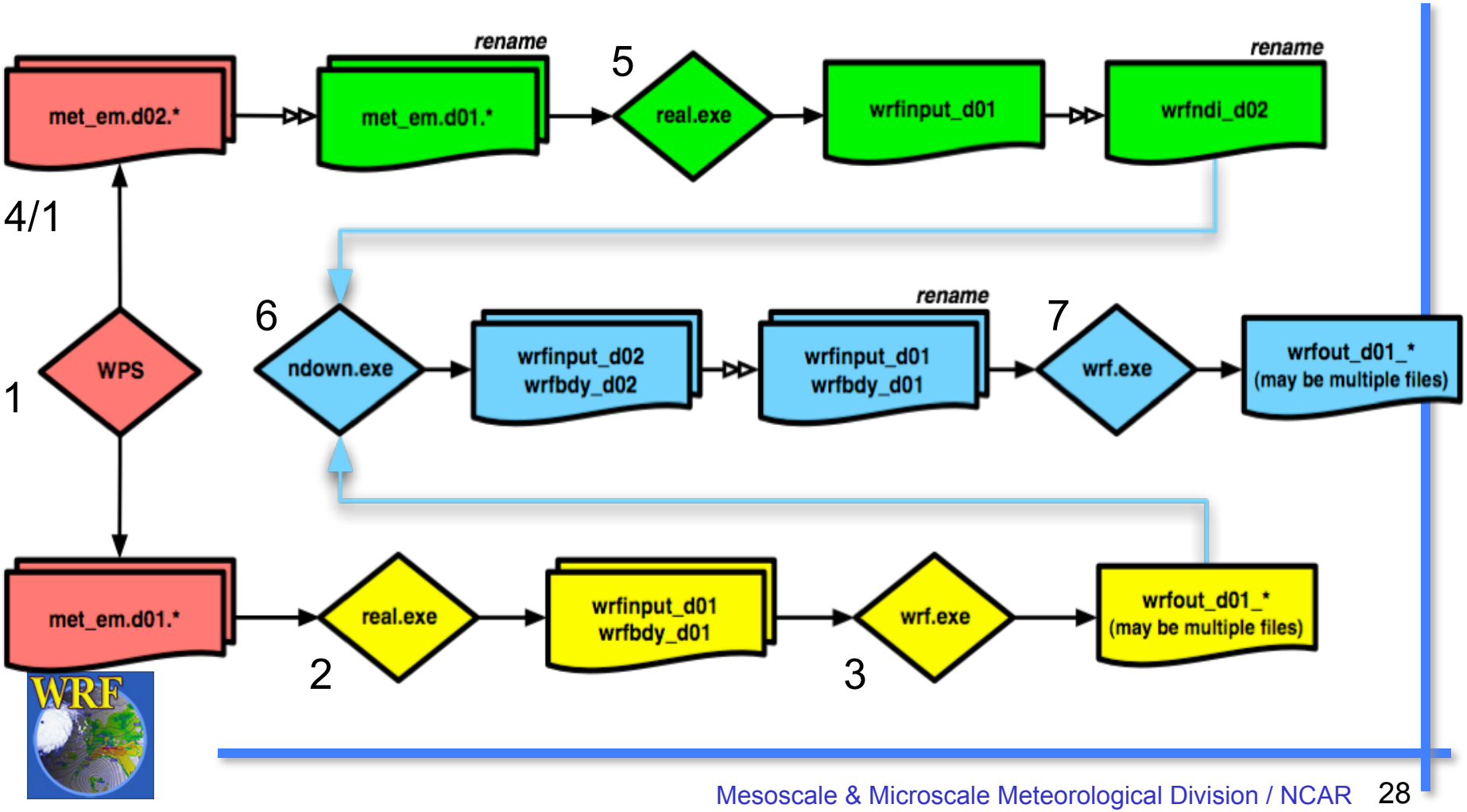
- Also specify initial nest location

  `i_parent_start, j_parent_start`



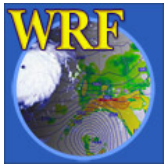
One-way Nesting: Two separate runs

ARW only *(also see p5-14 in User's Guide)*



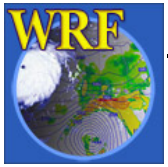
Summary

- NMM:
  - Two-way nesting, two inputs (**`met_nmm.d01.*`** and **`geo_nmm_nest*)`**
  - One-way, concurrent run (**`feedback=0`**)
- ARW:
  - Two-way, without nest input files (**`input_from_file=.f.`**)
  - Two-way, with nest input files (**`input_from_file = .t.`**)
  - Two-way, with static nest input only (**`input_from_file=.t.`**, **`fine_input_stream = 2`**)
  - One-way, concurrent run (**`feedback = 0`**)
  - One-way, separate runs (treated like two single domain runs, with ***`ndown`***)
  - Two-way, specified moving nest run
  - Two-way, automatic vortex tracking run



Notes about Nesting

- When should I use nests?
  - Input data resolution is too coarse (for example, reanalysis data)
  - Would like to simulate convection, topography- and/or landuse-forcing, etc.
  - Would like to provide better boundary conditions for the area of interest: boundary conditions from external sources are typically 3 – 6 hourly, while nested boundary conditions are in minutes (coarse domain time step)
  - There isn't sufficient computing resources
- Nest domain sizes should not be too small
  - No less than 100x100
  - Avoid boundary zones that are about 10 grid point wide
  - Avoid 'sweeping' effect from lateral boundaries
  - Aviod placing nest boundaries over high mountains



References

- Information on compiling and running WRF with nests, and a more extensive list of namelist options and their definition / explanations can be found in the ARW and NMM User's Guide, Chapter 5
- Start with namelist templates in `test/` directory
- Practice with online tutorial, and in the class.